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Genetic variability and association analysis for yield and yield components in indigenous and exotic collections of vetiver (*Vetiveria zizanioides* (L.) Nash)

R K Lal

Central Institute of Medicinal and Aromatic Plants
Lucknow - 226 015, India.

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Abstract

The variability in genetic parameters and their influence on growth and yield of vetiver (*Vetiveria zizanioides*) was studied in 45 indigenous and exotic collections. Considerable variability in morphometric traits was recorded in these collections. Strongly positive and significant correlations were found between plant height and root length and oil yield; root length and oil content; fresh root yield and dry root yield and oil yield; dry root yield and oil yield, and oil content and oil yield. Positive and significant associations were also observed between plant height and root width and fresh root yield; root length and root width. These traits may form a good selection criteria for improvement of essential oil yield in vetiver.

Keywords : heritability, variability, vetiver, *Vetiveria zizanioides*.

Introduction

Vetiver (*Vetiveria zizanioides* (L.) Nash) (Poaceae) is a perennial, densely tufted grass, the roots of which are a source of *khus* (vetiver) oil which has considerable significance in the essential oil industry. Vetiver is a native of India and occurs widely in the Indian subcontinent, especially in parts of Uttar Pradesh, Rajasthan and peninsular India, particularly along river banks and marshy lands. In our research programme on improvement of vetiver, a large number of genetic stocks/clones were assembled from different parts of India along with four exotic collections from Thailand, Ghana, Reunion Island and Indonesia with a view to study the genetic variability and to select promising lines suitable for high root and oil yields of better quality. In crop breeding programmes prior knowledge of various genetic parameters and their influence on growth and yield of crops is imperative. Therefore, the nature, amount and magnitude of genetic parameters and their influence on character associations for morpho-economic traits was studied in vetiver.

Materials and methods

A large number of clones/genetic stocks of vetiver were assembled at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow (India), from wild/cultivated sources from various places of India and abroad. Among the 120 germplasms/collections available, 45 genetic stocks [Uttar Pradash (36), Rajasthan (1), Delhi (3), Kerala (3), Indonesia (1) and Reunion Island(I)] were used in this study. The collections were grown in a randomized block design repeated twice in a net plot size of 1.25 sqm, under normal fertility regime (80:40:40 kg N, P and K/ha). Each plot consisted of a single row of 2.5 m each 50 cm apart (total 5 plants in each row). The trials were undertaken at the Research Farm of CIMAP, Lucknow (India) (26.5°N, 80.5° E and 120 m above MSL; annual rainfall 53.21 cm). The plants were uprooted 18 months after planting for recording of observations.

Morphometric data were recorded for nine economic traits, namely, plant height, tillers per plant, leaf width, leaf length, root length, root

Table 1. Mean performance of accessions of vetiver

Acc. No.	Plant height (cm)	Tillers/ plant	Leaf width (cm)	Root length (cm)	Root width (mm)	Fresh root yield (g/plot)	Dry root yield (g/plot)	Oil content (%)	Oil yield (g/plot)
MBR-1	172.5	263.0	0.38	49.0	0.28	500	250	0.80	2.02
MBR-2	160.0	235.0	0.40	45.5	0.35	270	160	0.59	0.95
MBR-3	152.5	247.5	0.45	43.0	0.40	200	120	0.92	1.11
MBR-4A	180.0	252.5	0.40	48.5	0.28	750	500	0.40	2.00
MBR-5	162.5	300.0	0.43	39.5	0.33	800	400	1.20	4.81
MBR-6	75.0	277.5	0.38	54.0	0.30	60	45	1.20	0.54
MBR-7	172.5	200.0	0.48	43.5	0.35	100	70	0.50	0.34
GHT-1	162.5	212.5	0.43	49.3	0.30	280	190	0.90	1.72
MBJ-1	157.5	260.0	0.40	43.5	0.33	500	300	0.90	2.68
MBJ-2	165.0	285.0	0.33	53.5	0.38	120	80	0.73	0.59
MBJ-3	167.5	305.0	0.35	47.0	0.35	300	140	1.05	1.48
BMH-1	180.0	299.0	0.56	45.8	0.35	550	200	1.00	2.02
BMH-2	170.0	210.0	0.35	52.5	0.40	60	45	0.89	0.40
BMH-3	177.5	302.5	0.40	46.5	0.35	60	45	1.35	0.63
BMH-4	182.5	257.5	0.40	49.5	0.40	380	200	1.20	2.39
BDP-1	289.5	352.5	0.56	68.5	0.45	740	375	1.20	4.50
KS-1	175.0	295.0	0.50	45.5	0.35	150	80	0.80	0.64
Sugandha	165.0	215.0	0.48	46.0	0.35	340	250	0.94	2.35
Pusa Hyb-28	142.5	200.0	0.43	41.0	0.25	205	165	0.73	1.20
Pusa Hyb-8	129.5	240.0	0.45	39.5	0.35	295	180	0.45	0.81
Pusa Hyb-7	162.5	305.0	0.40	31.0	0.25	140	68	0.35	0.24
RI-I	158.5	345.0	0.38	35.0	0.43	395	310	0.78	2.40
MBR-4B	129.5	200.0	0.35	38.5	0.35	300	170	0.38	0.64
OD-1	182.5	245.0	0.30	39.5	0.43	200	123	0.28	0.34
BL-1	177.5	245.0	0.53	30.0	0.28	158	80	0.75	0.60
BMM-1	167.5	290.0	0.30	31.5	0.28	158	78	0.63	0.49
BB-1	145.0	285.0	0.41	30.0	0.33	300	225	0.45	1.02
IN-1	170.0	257.5	0.40	29.0	0.43	285	190	0.58	1.09
BJ-1	182.5	261.0	0.53	38.5	0.35	200	123	0.45	0.55
GHT-2	172.5	295.0	0.55	38.5	0.28	405	330	0.38	1.24
BST-1	127.5	352.5	0.58	22.5	0.25	305	175	0.45	0.79
BKT-1	162.5	272.5	0.45	35.5	0.30	205	120	0.48	0.57
KH-2	192.5	210.0	0.35	27.5	0.28	495	215	0.73	1.56
KH-3	142.5	310.0	0.30	32.5	0.40	445	315	0.58	1.82
KH-8	185.0	295.0	0.35	45.0	0.33	120	78	0.60	0.47
KH-11	182.5	395.0	0.40	55.0	0.35	145	73	0.55	0.40
KH-16	157.5	345.0	0.38	57.5	0.40	158	83	0.38	0.31
KH-23	142.5	290.0	0.38	40.0	0.33	300	225	0.68	1.52
KH-26	170.0	245.0	0.33	33.5	0.28	445	325	0.78	2.52
KH-30	142.0	290.0	0.30	52.5	0.30	300	170	0.65	1.11
KH-40	132.5	290.0	0.50	39.5	0.28	245	100	0.58	0.58
KH-41	172.5	290.0	0.38	40.0	0.25	345	185	0.48	0.88
KH-42	182.5	390.0	0.58	38.0	0.45	300	165	0.80	1.32
KH-55	192.5	200.0	0.35	27.5	0.28	495	215	0.73	1.56
KS-2	160.0	315.0	0.43	39.5	0.35	400	315	0.68	2.13
Range	75.0-289.5	200.0-395.0	0.30-0.58	22.5-68.5	0.25-0.54	60-800	45-500	0.28-1.35	0.24-4.81
CD (1%)	0.13	25.3	0.06	4.2	0.05	70	63	0.17	0.54

width, fresh root yield, dry root yield, oil content and oil yield. Oil content was estimated by hydro-distillation of 1 kg shade dried roots of each clone for 16 h in Clevenger's apparatus of 10 l capacity (Clevenger 1928). The mean data collected (averaged over samples of 5 hills/plot) were subjected to statistical analysis for ANOVA, correlations at phenotypic, genotypic and environmental levels and other allied genetic parameters.

Results and discussion

Analysis of variance, means, range, critical difference (CD 1%), critical variance (CV%), and coefficient of variations due to genotype (CVg%) and phenotype (CVp%) revealed highly significant differences ($P<0.01$) for all the nine characters which indicated the existence of considerable genetic variability among the genetic stocks (Table 1). This confirms our earlier study on genetic diversity of vetiver using multivariate analysis (Lal *et al.* 1997a). The heritable proportion of phenotypic variance reflected by the size of genotypic variance (g) in relation to phenotypic variance (p) is expressed as heritability in the present case, was very high.

All the characters influencing oil yield of plants were highly heritable and hBS ranged from 86.8 to 97.9% (Table 2). A high heritability (hBS) estimate as noticed in the present study as heritability broad sense (hBS) is a reliable parameter/indicator for selection of desirable types in vetiver as environment had little effect on the expression of these factors. Hence, the authencity of the selection differential(s) might be fully ensured to obtain faster selection gains by repeated clonal selection in breeding programmes (Lal *et al.* 1997b). Since estimates of heritability in broad sense (hBS%) was high for tillers per plant, fresh and dry root and oil yield and the crop is by and large vegetatively propagated, these traits might be highly amenable to direct selection for genetic improvement in a short span of time and hBS alone has to be exploited for clonal selection in this crop.

In addition to high variation and heritability, the associations among characters also have a direct bearing on selection. In this study the genotypic correlation was higher than the phenotypic one in most of the characters (Table 3). The correlations at phenotypic level are the direct expression of linkage at genotypic level, positive association due to coupling and negative association due to repulsion phase. In asexually reproducing crop species, both coupling and repulsion phase of linkage remain fixed over all clonal generations. Therefore, character-constellations are difficult to be altered by clonal selection.

Leaf width had an antagonistic association with root length and root width with dry root yield. Plant height was strongly and positively associ-

Table 2. Variability of genetic parameters in vetiver

Character	Genetic parameter					
	Genotypic variance (g)	Phenotypic variance (p)	Environmental variance (e)	CVg (%)	CVg (%)	h(BS) (%)
Plant height (cm)	0.078	0.080	0.002	17.21	16.95	97.0
Tillers/plant	2372.260	2465.350	88.090	17.67	17.99	96.4
Leaf width (cm)	0.003	0.003	2.459	18.66	19.43	92.2
Root length (cm)	79.610	82.070	0.001	21.24	82.07	97.0
Root width (mm)	0.006	0.007	0.001	16.17	17.36	86.8
Fresh root yield (g/plot)	30901.480	51578.170	676.690	57.94	58.57	97.9
Dry root yield (g/plot)	10868.590	11425.060	552.480	57.19	58.64	95.1
Oil content (%)	0.069	0.073	0.004	36.94	38.04	94.3
Oil yield (g/plot)	0.995	1.035	0.041	76.05	77.59	96.0

hBS = Heritability broad sense; CVg and CVp = Coefficient of variation due to genotype and phenotype

Table 3. Genotypic (G), phenotypic (P) and environmental (E) correlations, coefficients among plant characters of 45 accessions in vetiver

Character		Plant height	Tillers/ plant	Leaf width	Root length	Root width	Fresh root yield	Dry root yield	Oil content	Oil yield
Plant height	G	-	0.12	0.23	0.30**	0.35*	0.36*	0.24	0.18	0.38**
	P		0.17	0.21	0.29*	0.31*	0.35*	0.23	0.18	0.39**
	E		0.21	-0.10	0.02	-0.15	0.04	0.20	0.27	0.50*
Tillers/ plant	G		-	0.28	0.12	0.24	0.10	0.06	0.03	0.11
	P			0.25	0.12	0.23	0.11	0.05	0.03	0.10
	E			-0.11	0.09	0.14	0.23	-0.05	0.01	-0.03
Leaf width	G			-	-0.04	0.03	0.16	0.09	0.07	0.14
	P				-0.04	0.01	0.15	0.07	0.07	0.12
	E				-0.15	-0.23	-0.08	0.24	0.07	-0.21
Root length	G				-	0.35*	0.03	-0.05	0.47**	0.18
	P					0.32*	0.03	-0.04	0.40**	0.18
	E					-0.03	-0.11	0.18	-0.03	0.13
Root width	G					-	-0.02	0.01	0.23	0.18
	P						0.01	-0.02	0.22	0.16
	E						0.30*	-0.20	0.16	-0.06
Fresh root yield	G						-	0.94**	0.19	0.88**
	P							0.90**	0.18	0.85**
	E							-0.21*	-0.09	-0.29**
Dry root yield	G							-	0.07	0.81**
	P								0.06	0.80**
	E								-0.02	-0.63**
Oil content	G								-	0.54**
	P									0.54**
	E									0.61**
Oil yield	G									-
	P									-
	E									-

*, ** = $P < 0.05$ and $P < 0.01$, respectively

ated with oil yield, root length, root width and fresh root yield. Further, positive association of root length with oil content, fresh root yield with dry root yield and oil yield; dry root yield with oil yield; and oil content with oil yield manifested highly significant and favourable correlations. Similarly, root length was correlated with root width, oil content and plant height. Thus, plant height by itself may be a good direct selection criterion to obtain promising lines with longer roots in vetiver aiming at a better oil yielder and a good soil binder.

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